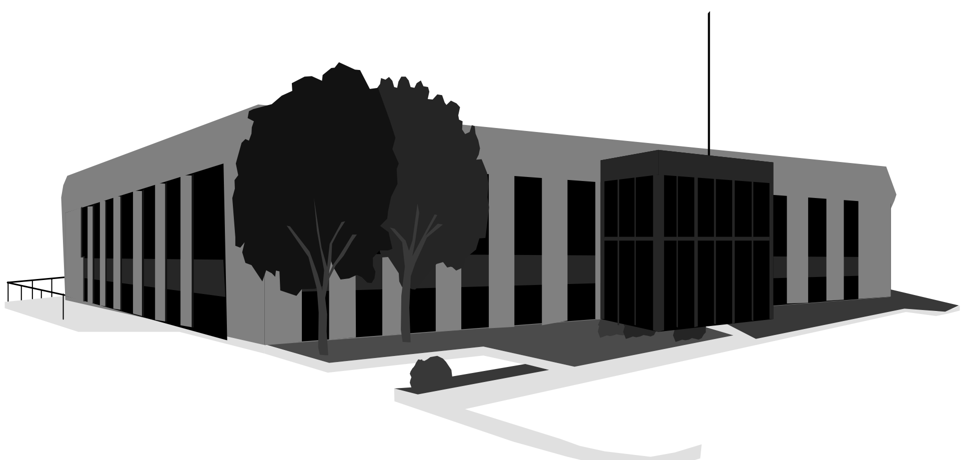
INDOOR AIR QUALITY ASSESSMENT

Bernardston Elementary School
Pioneer Valley Regional School District
School Road
Bernardston, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Lynn Rose, Western Massachusetts Coalition for Occupational Safety and Health (Western MassCOSH) in cooperation with the Pioneer Valley Regional School District (PVRSD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Bernardston Elementary School, School Street, Bernardston, Massachusetts. On March 21, 2001, Mike Feeney, Chief of the Emergency Response/Indoor Air Quality (ER/IAQ) Program, BEHA, conducted an indoor air quality assessment. Accompanying Mr. Feeney was Ms. Rose.

Bernardston Elementary School is a multi-wing red brick building. The original building was constructed during the 1950's. A peaked roof was added in the 1960's over the original wing's flat roof. An addition was constructed around 1972. The building underwent renovations that were completed in 1997. The school consists of general classrooms, art room, library, computer lab, gymnasium, cafeteria, and office space. Windows in the school are openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school contains a student population of approximately 200 and a staff of approximately 20. The tests were taken under normal operating conditions. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in nine out of twenty-three areas surveyed, indicating a ventilation problem in some areas of the school. Ventilation is provided by air handling units (AHU) installed inside the attic crawlspace (see Picture 1). Fresh air is drawn into the AHU through vents that exist in gables around the building or beneath the roof edge of the gymnasium. Fresh air is distributed to each classroom by a ceiling-mounted fresh air diffuser. All fresh air supplies were operational during the assessment. Exhaust ventilation in classrooms is provided by ceiling-mounted exhaust grilles that were also operational. The principal's and main office suite has its exhaust vent located in the ceiling of the main office storage closet. Air is drawn from the rooms by means of a passive door vent located in the closet door.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The last balancing of these systems was reportedly performed in 1998, after the renovations. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 68^{o} F to 76^{o} F. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 20 to 29 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60. Relative humidity levels in the building would be expected to drop during winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water penetration was noted through the exterior doorframes in the wing of classroom 102. Water damage to the wooden threshold indicates that water may be moistening the carpeting around the doorframe (see Picture 2). The source of water appears to be an incomplete gutter that is installed over the classroom exterior doors (see Picture 3). No gutter and downspout system is installed along the edge of the peaked roof. Rainwater collecting on the roof rolls off the edge to collect and drain from the building. This design is problematic due to cement slabs used as exterior door thresholds existing beneath the roof edge. Splashing rainwater can lead to chronic moistening of the exterior wall and doors. These gutters are not connected to downspouts to direct rainwater from the base of the building, and has resulted in chronic moistening of the exterior brickwork, as well as the louvers of the abandoned fresh air intake vent for the unit ventilator (univent) in classroom 102 (see Picture 3). Wetting of the louvers can lead to water penetration into the abandoned univent.

A musty/mold-like odor was detected in the computer room. A plant was observed over water stained carpeting in this room (see Picture 4). Mold colonization of the carpet from repeated moistening due to plant watering is the most likely cause of this odor. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended. Plants were noted in other areas. In one instance plants were stored inside cardboard boxes, which doubled as drip pans (see Picture 5). Cardboard in a porous material, which if wetted repeatedly, can provide a medium for microbial growth. Plants should be equipped with proper drip pans and be located away from the air stream of mechanical ventilation to prevent aerosolization of dirt, pollen or mold.

As mentioned previously, several classrooms in the front of the building are equipped with univents that were abandoned after the 1997 renovations. The fresh air intake vents are open to the outdoors (Picture 3) and can serve as a means of drafts and water vapor to penetrate into the building. In addition, these vents can also serve as a means for water from melting snow covering the vents to penetrate into the interior of each univent. Abandoned ventilation equipment should have the fresh air intakes rendered air and water tight to prevent moisture from breaching the building envelope and leading to uncontrolled drafts and water penetration.

The hallway outside classroom 102 had four water damaged ceiling tiles, which can indicate leaks from either the roof or plumbing system. Water damaged ceiling tiles can serve as a mold growth medium if repeatedly moistened.

PVRSD officials reported a chronic problem with water penetration through an exterior door in the cafeteria. No drain exists outside of the kitchen door threshold to remove collected water. The pavement around this door slopes towards the cafeteria door (see Picture 6). The pattern of sediment on the tarmac also indicates that rainwater follows the building exterior wall and travels down the slope towards this door (see Picture 7). Above this area is a section of the roof eave that does not have a gutter downspout system. Rainwater from this section of the roof falls directly into this area, exacerbating the collection of water.

Also contributing to the problem is the high water table beneath this section of the building. The land on the opposite side of the kitchen wing slopes toward the cafeteria wall (see Picture 8). The boiler room, which is also in the general area of the cafeteria, has a hole in the floor. A plastic–lined hole was found filled with groundwater to a level of 1-2 inches below the floor (see Picture 9). With the high water table beneath the cafeteria wing, efforts to redirect runoff from the roof and parking lot should be made to prevent further flooding of the cafeteria/kitchen.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. BEHA staff noted complaints related to exhaust infiltration from busses. These vehicles discharge and embark passengers in the front of the school building, near where a gable-mounted fresh air intake is located (see Picture 1). Idling busses at the front of the building can result in vehicle exhaust entrainment by the mechanical ventilation system and open windows. Under certain weather conditions this may provide opportunities for exposure to combustion products such as carbon monoxide. Air monitoring for a constituent of vehicle exhaust (carbon monoxide) was measured in classrooms serviced by this fresh air intake during bus embarkation the afternoon of the assessment. No vehicle exhaust odors or measurable levels of carbon monoxide were detected within these classrooms at the time of the assessment.

PVRSD personnel also reported that vehicle exhaust odors have been reported in classrooms above the kitchen exterior door that serves as the loading dock area for the school (see Picture 10). The classrooms above this area are installed with window-mounted air conditioners, which may be of a type that introduces fresh air from outdoors. The operation of these window-mounted air conditioners, as well as the opening of windows above the kitchen door, can serve as pathways for vehicle exhaust to penetrate into classrooms from idling delivery vehicles. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1986).

Of note is the use of different volatile organic compound containing products in the building. The following materials were found in classrooms:

Rubber cement- Rubber cement (see Picture 11) contains n-hexane, which can be irritating to the eyes, nose and throat; in addition n-hexane is an extremely flammable material. Local exhaust ventilation should be utilized when this material is used.

Artificial Snow-This spray product, used to frost windows, contains flammable materials. The product contains heptane and xylene (see Pictures 12) (CPC, 1998). Heptane and xylene are substances that are associated with irritation to the eyes, nose and throat. It should only be used with proper exhaust ventilation and not with children in close proximity.

Dry Erase markers-Some classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Under the Labeling of Hazardous Art Materials Act (LHAMA), art supplies containing hazardous materials that can cause chronic health effects must be labeled as required by federal law (USC, 1988). The use of art supplies containing hazardous materials that can cause chronic health effects should be limited to times when students are not present and only when adequate exhaust ventilation is available.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Remove plant from floor in computer room. Remove water damaged carpeting beneath the plant. Disinfect the nonporous material below the removed carpeting with an appropriate antimicrobial agent and then clean thoroughly with soap and water. Replace carpeting as needed and avoid placing plants on carpeting.
2. Install downspouts at either end of the gutter system shown in Picture 3 to prevent splashing rainwater from damaging the exterior wall and penetrating through door

thresholds. Recaulk the door threshold and doorframe to prevent water penetration. Consider removing carpeting from door threshold.

3. Examine the feasibility of redirecting groundwater from the slope toward the kitchen door. This may be accomplished by installing a gutter/downspout system to collect rainwater from the roof that is falling from the eave into the slope towards the kitchen door. A raised section (called a berm) of tarmac installed at the wings wall corner could by used to direct water away from the kitchen door and also serve as a speed bump (see Picture 13).
4. Render univent fresh air intakes airtight and watertight.
5. Adjust the fresh air intakes to deliver more fresh air to various areas.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Discard cardboard used as drip pans for plants. Plants should be equipped with drip pans of a non-porous material (e.g., plastic). Examine drip pans periodically for mold growth and disinfect areas with an appropriate antimicrobial where necessary.
8. Repair/replace any water-damaged ceiling tiles. Examine above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate

antimicrobial. Building occupants should report any roof leaks or other signs of water penetration to school maintenance staff for prompt remediation.

9. Post a sign by the loading dock instructing vehicle operators to shut down engines in compliance with Massachusetts law. Schedule deliveries after school hours. If no other option, provide teachers in rooms above the loading dock with a schedule for deliveries so that window-mounted air conditioners can be deactivated and windows closed during deliveries to prevent vehicle exhaust odor penetration.
10. Consider relocating bus passenger discharge and embarkation to avoid vehicle exhaust entrainment by the ventilation system during southerly wind conditions.
11. Discontinue the use of artificial snow.
12. Consider replacing art and school supplies containing materials that require labeling under LHAMA with water-based materials to reduce VOCs in classrooms.
13. Acquire current Material Safety Data Sheets for all products that contain hazardous materials and are used within the building, including office supplies, in conformance with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

CPC. 1998. Material Safety Data Sheets for Santa Snow Frost. Chase Products Company, Maywood, IL.

MGL. 1986. Stopped motor vehicles; Operation of Engine; Time Limit; Penalty. Massachusetts General Laws. M.G.L. c. 90:16A.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

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SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

USC. 1988. Labeling of Hazardous Art Materials Act (LHAMA). U.S. Code. 15 U.S.C. 1277(b)(1).

Picture 1

AHU Fresh Air Intake

Picture 2

Water Damage to Door Threshold in Close Proximity the Wall-To-Wall Carpeting

Picture 3

Open Ended Gutter over Exterior Doors, Note Darkened Wall Brick Which Indicates Repeated Water Moistening, Arrow Denotes Abandoned Univent Fresh Air Intake

Picture 4

Plant On Carpeting in Computer Room

Picture 5

Plants In Cardboard Boxes

Picture 6

Ground Level Shot of Kitchen Door Threshold, Note Lack of Drain and Slope towards Threshold

Picture 7

Tarmac Sloping towards Kitchen Door, Arrows Denote Rainwater Pathway as Indicated by Collected Sediment

Picture 8

Ground Sloping towards Cafeteria Wall on Wing Wall opposite Kitchen Door

Picture 9

Collected Groundwater in Hole in Boiler Room, Arrow Indicates Water Level Line on Side of Hole

Picture 10

Window-Mounted Air Conditioners above Loading Dock

Picture 11

Containers of Rubber Cement

Picture 12

Artificial Snow Container

Picture 13

Line Indicates Possible Location of Berm to Direct Rainwater Runoff Away From Kitchen Door

TABLE 1

Indoor Air Test Results – Bernardston Elementary School, Bernardston, MA – March 21, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	415	51	29					
102	800	71	24	14	Yes	Yes	Yes	Supply and exhaust working, water damage at door threshold to outside, moisture accumulating at edge of building-staying wet due to organic matter, 2 disconnected univents
101	819	68	29	13	Yes	Yes	Yes	Supply and exhaust working, 2 disconnected univents, 2 windows open
Hallway outside 102								4 water damaged CT
104	586	72	24	0	Yes	Yes	Yes	Door open
103	890	73	25	14	Yes	Yes	Yes	Door open
Counselor's Office	566	73	22	0	Yes	Yes	Yes	Door open
107	908	73	24	20	Yes	Yes	Yes	

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Bernardston Elementary School, Bernardston, MA – March 21, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
109	704	72	23	17	Yes	Yes	Yes	
Computer Room	571	73	22	3	Yes	Yes	Yes	25 computers, plant, carpeting-odor, door open
Music Room	464	74	20	0	Yes	Yes	Yes	Door open
	514	76	21	0	Yes	Yes	Yes	
118	530	76	20	3	Yes	Yes	Yes	Door open
Cafeteria	1030	70	29	50+	Yes	Yes	Yes	Passive exhaust to kitchen, 1 water damaged CT, door open
Gym	443	69	24	2	Yes	Yes	Yes	
Art Room	468	69	23	0	Yes	Yes	Yes	Door open
Library	490	73	22	1	Yes	Yes	Yes	Door open
Pre-school	542	73	23	0	Yes	Yes	Yes	
Teachers' Room	886	73	26	7	Yes	Yes	Yes	2 photocopiers, door open

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Bernardston Elementary School, Bernardston, MA – March 21, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
113	883	76	25	17	Yes	Yes	Yes	White board, door open
114	751	75	23	16	Yes	Yes	Yes	White board
112	681	75	22	14	Yes	Yes	Yes	White board, door open
111	876	74	23	15	Yes	Yes	Yes	Plants-cardboard
Main Office	852	74	23	1	No	Yes	Yes	Passive exhaust vent in closet, water cooler
Principal's Office	885	74	24	1	Yes	Yes	Yes	Passive exhaust vent

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